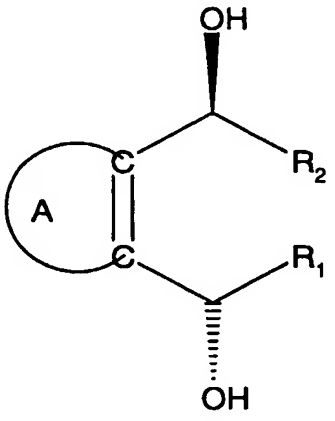
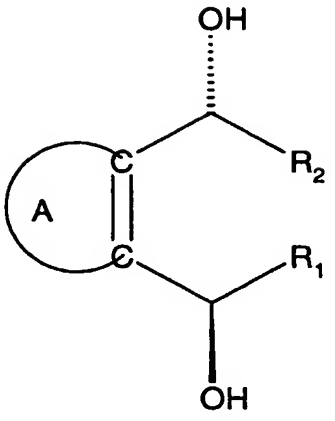
What is claimed is:

1. A method for the preparation of C_2-symmetric 1,4-diols of the formula IVA or IVB having a high enantiomeric purity



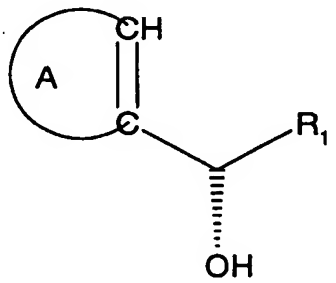
(IVA)



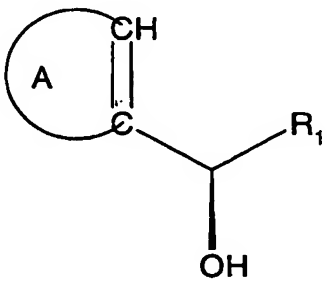
(IVB)

wherein ring A which includes the shown double bond forms a mono-, di- or polycyclic aromatic or heteroaromatic ring and R_1 and R_2 are, independently of each other, an organic moiety,

the process or method comprising reacting an α-(aryl or heteroaryl)-α-substituted alkanol compound of the formula IA (for the synthesis of a compound of the formula IVA) or IB (for the synthesis of a compound of the formula IVB)

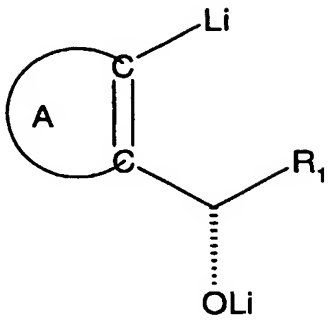


(IA)

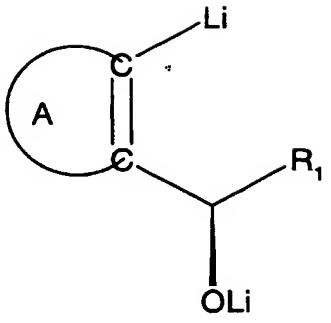


(IB)

wherein ring A and R_1 are as defined under formula IVA and IVB, with a lithiating reagent, obtaining an intermediate of the formula IIA (from IA) or IIB (from IB),



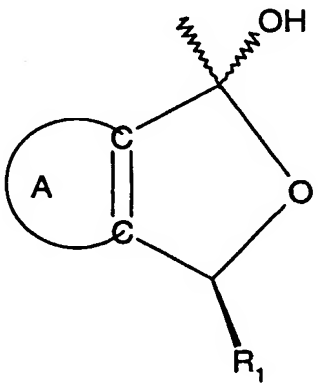
(IIA)



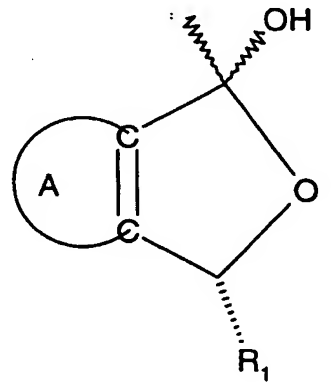
(IIB)

wherein ring A and R_1 have the meanings given under compounds of the formulae IVA and IVB.

2. The process according to claim 1, further comprising reacting the lithiated product of the formula IIA or IIB, respectively, with an N,N-di-alkyl-formamide to a hemiacetal compound of the formula IIIA (from IIA) or IIIB (from IIB),



(IIIA)



(IIIB)

wherein ring A, R_1 and R_2 have the meanings indicated for compounds of the formula IVA and IVB, and subsequently with a Grignard reagent of the formula R_2MgX wherein R_2 is an organic moiety and X is halogen or, alternatively, using corresponding lithium, zinc or other metal comprising compounds that allow for introduction of R_2; to yield the corresponding compounds of formula IVA (from IIIA) and IVB (from IIIB).

3. The method according to claim 1, further comprising reacting an aldehyde of the formula VI

$$R_2\text{-}CH{=}O \qquad (VI)$$

wherein R_2 is as defined for compounds of the formulae IVA and IVB, with the intermediate of the formula IIA to yield a compound of the formula IVA or of the formula IIB to yield a compound of the formula IVB.

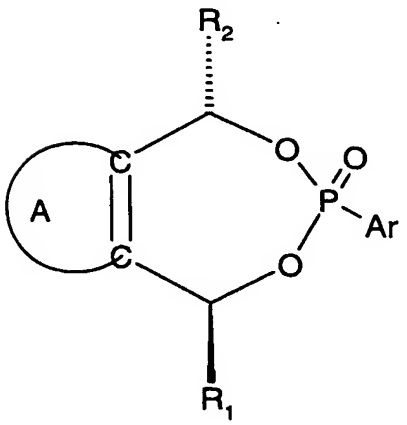
4. A compound of the formula IVA or IVB as shown in claim 1 having a high enantiomeric purity, wherein ring A, R_1 and R_2 are as defined in claim 1, with the proviso that R_1 and R_2 are not simultaneously methyl or ethyl.

5. A process for the preparation of a ligand of the formula XA, XA*, XB or XB* given below,

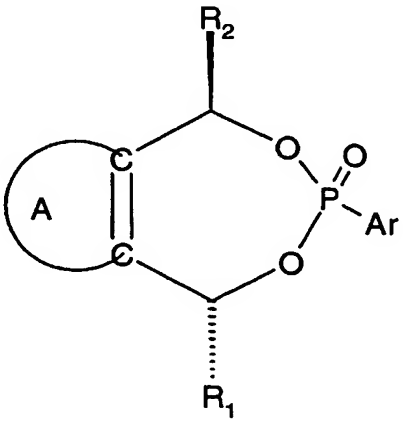
said process comprising reacting a compound of the formula IVA (for the synthesis of a compound of the formula XA) or IVB (for the synthesis of a compound of the formula XB) obtained according to any one of claims 1 to 3 with an aryl phosphinic acid halogenide of the formula VII;

$$Ar\text{-}P(=O)(Hal)_2 \qquad (VII)$$

wherein Ar is aryl, especially phenyl, and Hal is halogen, especially chloro, in the presence of a base resulting in the formation of a phosphonate ester compound of the formula VIIIA (from IVA) or VIIIB (from IVB), respectively,



(VIIIA)



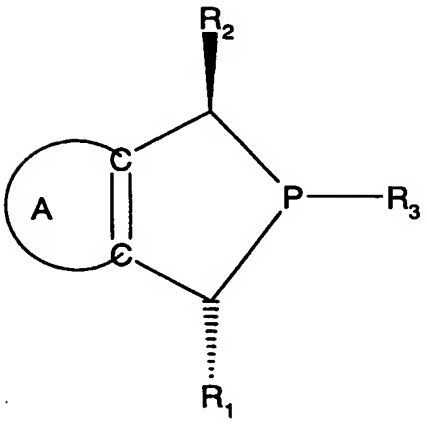
(VIIIB)

wherein ring A, R_1 and R_2 have the meanings indicated for compounds of the formula IVA and IVB and Ar is aryl, and then reacting a compound of the formula VIIIA or VIIIB with a phosphine of the formula IX or IX*,

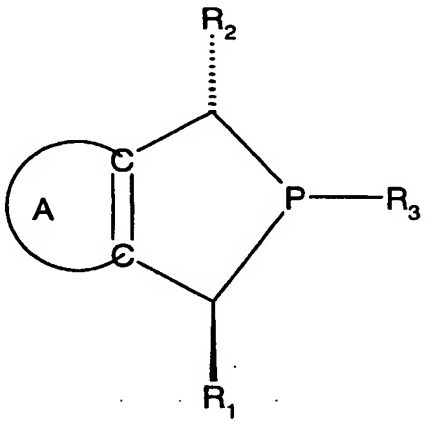
R_3-PH_2 (IX)

H_2P-R_3*-PH_2 (IX*)

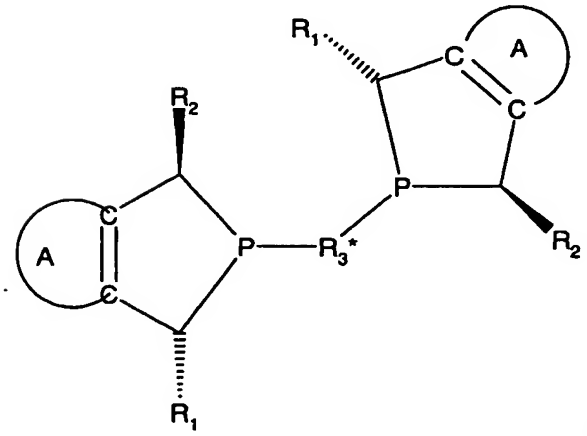
(or the corresponding borane adduct thereof) wherein R_3 is a monovalent, R_3* a bivalent organic moiety that can be bound to phosphorus, resulting in a phospholane compound of the formula XA or XA* (from VIIIA); or XB or XB* (from VIIIB), respectively,



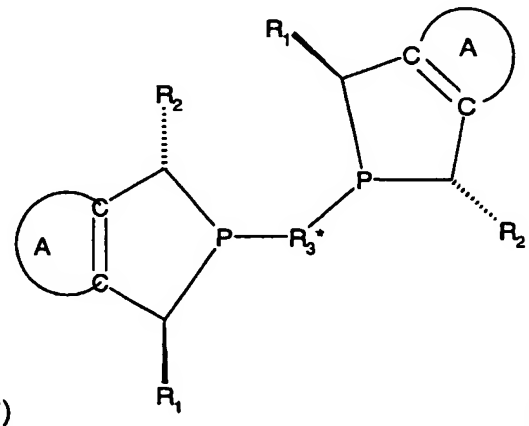
(XA)



(XB)



(XA*)



(XB*)

wherein ring A, R_1 and R_2 have the meanings indicated for compounds of the formula IVA or IVB and R_3 or R_3* is as defined under formulae IX and IX*, respectively.

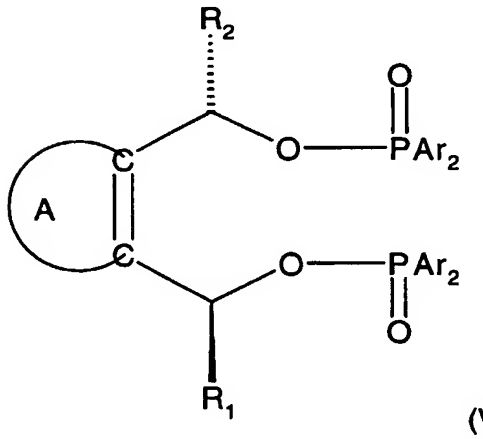
6. A ligand of the formula XA, XA*, XB or XB*, as shown and defined in claim 5.

7. A transition metal complex comprising a ligand of the formula XA, XA*, XB or XB*, as shown and defined in claim 5.

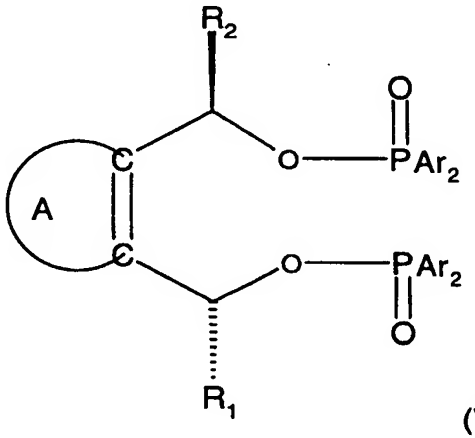
8. A process for the preparation of a ligand of the formula XA, XA*, XB or XB* given below, said process comprising reacting a compound of the formula IVA (for the synthesis of a compound of the formula XA) or IVB (for the synthesis of a compound of the formula XB) obtained according to any one of claims 1 to 3 with an aryl phosphinic acid halogenide of the formula VII';

$$Ar_2P(=O)Hal \qquad (VII')$$

wherein Ar is aryl, especially phenyl, and Hal is halogen, especially chloro, in the presence of a base resulting in the formation of a compound of the formula VIIIA' (from IVA) or VIIIB' (from IVB), respectively,



(VIIIA')



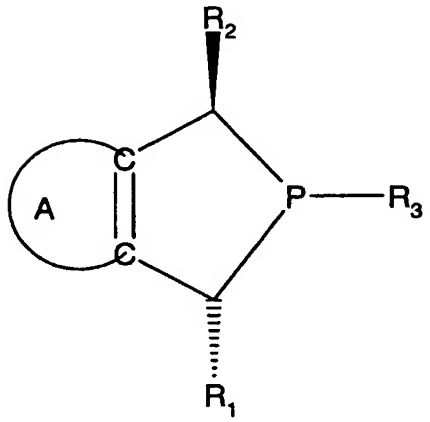
(VIIIB')

wherein ring A, R_1 and R_2 have the meanings indicated for compounds of the formula IVA and IVB and Ar is aryl, and then reacting a compound of the formula VIIIA' or VIIIB' with a phosphine of the formula IX or IX*,

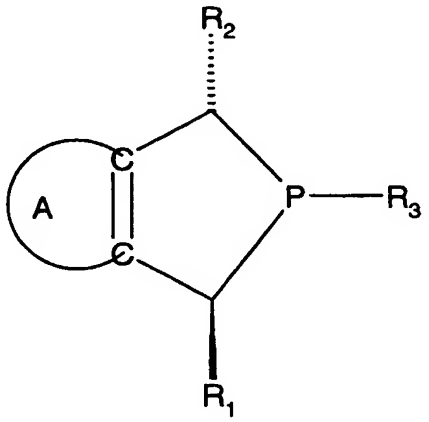
$$R_3\text{-}PH_2 \qquad (IX)$$

$$H_2P\text{-}R_3^*\text{-}PH_2 \qquad (IX^*)$$

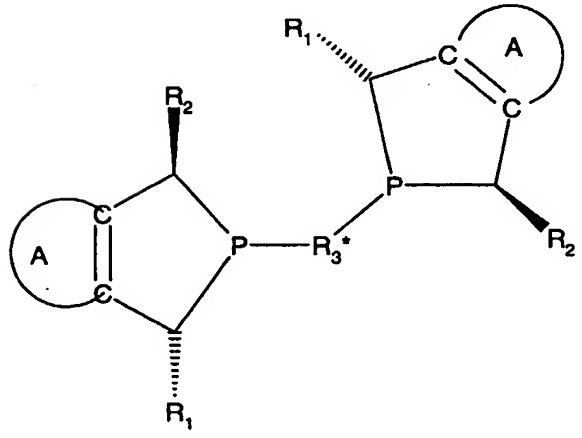
(or the corresponding borane adduct thereof) wherein R_3 is a monovalent, R_3^* a bivalent organic moiety that can be bound to phosphorus, resulting in a phospholane compound of the formula XA or XA* (from VIIIA); or XB or XB* (from VIIIB), respectively,



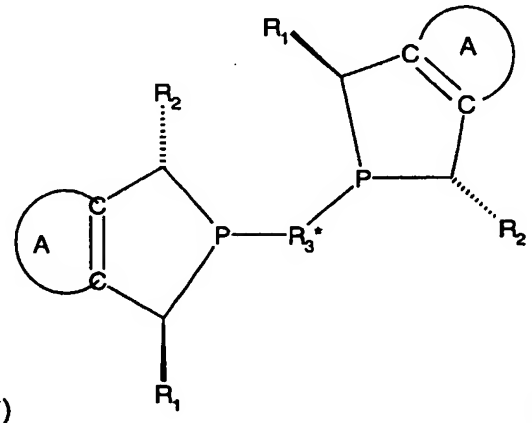
(XA)



(XB)



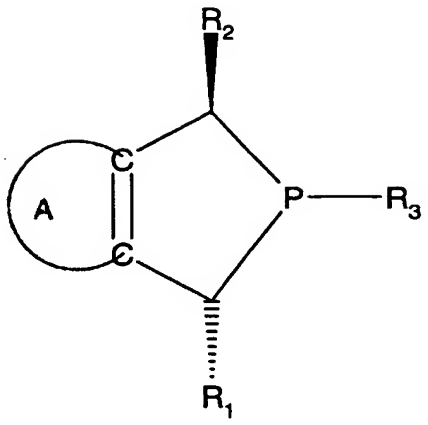
(XA*)



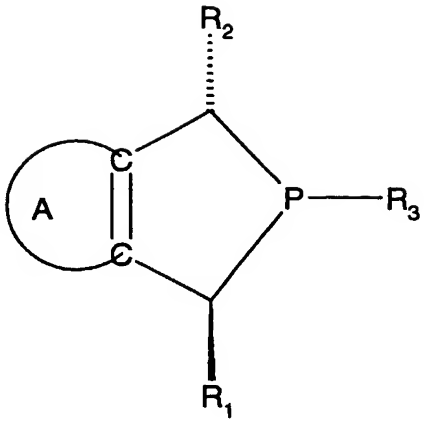
(XB*)

wherein ring A, R_1 and R_2 have the meanings indicated for compounds of the formula IVA or IVB and R_3 or R_3^* is as defined under formulae IX and IX*, respectively.

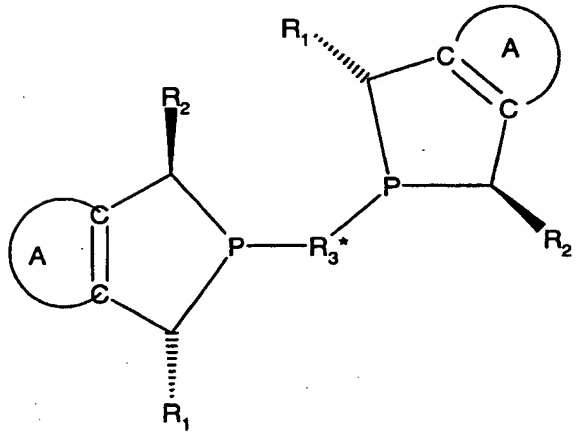
9. A process for the preparation of a compound of the formula XA, XA*, XB or XB*,



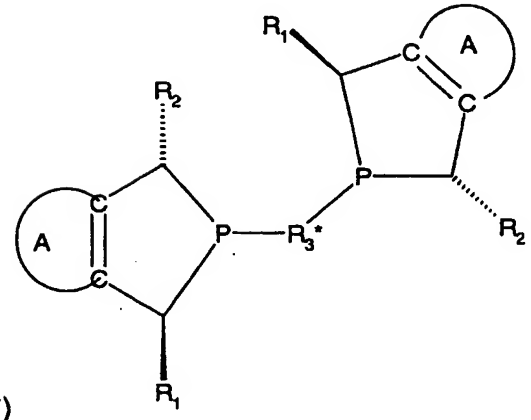
(XA)



(XB)



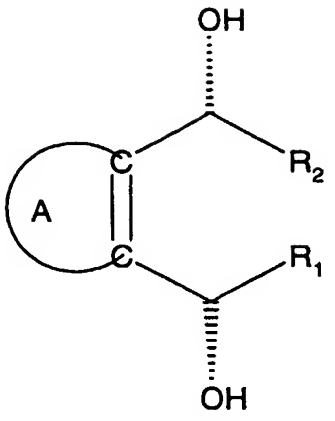
(XA*)



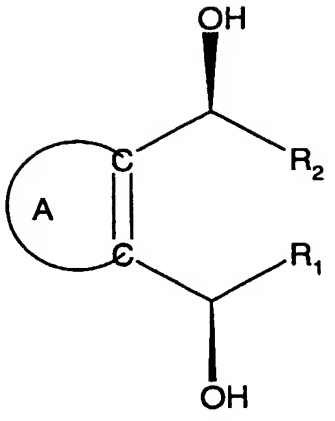
(XB*)

wherein ring A, R_1 and R_2 have the meanings indicated for compounds of the formula IVA or IVB in claim 1 and R_3 or R_3* is as defined under formulae IX and IX*, respectively

said process comprising reacting a compound of the formula IVA or IVB given in claim 1, or a mixture of a compound of the formula IVA and VA, or of a compound of the formula IVB and VB,



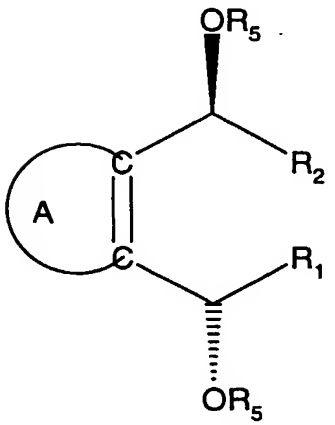
(VA)



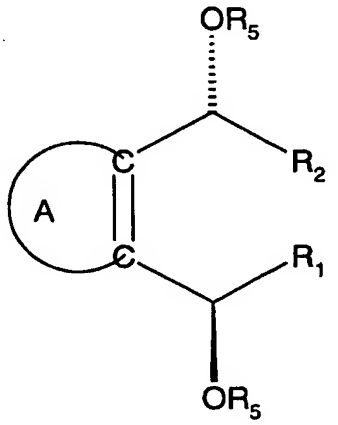
(VB)

wherein ring A, R_1 and R_2 have the meanings indicated for compounds of the formula IVA and IVB,

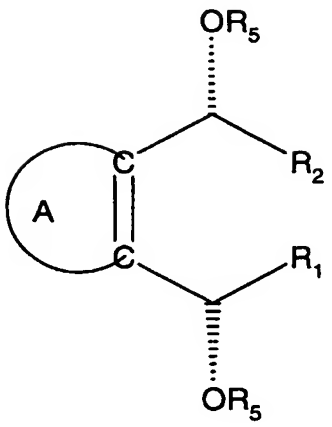
with an agent introducing an acyl protecting group, obtaining the corresponding bis-hydroxy-protected compounds of the formula IVA* (from IVA), IVB* (from IVB), or mixtures of a compound of the formula IVA* and VA* (from a mixture of a compound of the formula IVA and VA) or of a compound of the formula IVB* and VB* (from a mixture of a compound of the formula IVB and VB),



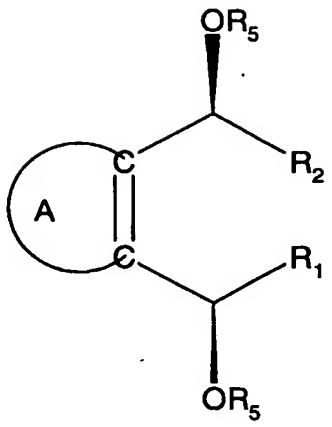
(IVA*)



(IVB*)



(VA*)



(VB*)

wherein ring A, R_1 and R_2 have the meanings indicated for compounds of the formula IVA and IVB and R_5 is acyl, an then reacting the compound or compounds to
the corresponding compounds of the formulae XA shown above with a compound of the formula IX,

$$R_3\text{-}PH_2 \qquad (IX)$$

or a borane adduct thereof, wherein R_3 is a monovalent organic moiety that can be bound to phosphorus,
or for a compound of the formula XA* shown above with a compound of the formula IX*,

$$H_2P\text{-}R_3^*\text{-}PH_2 \qquad (IX^*)$$

or a borane adduct thereof, wherein R_3^* is a bivalent organic moiety that can be bound to phosphorus, in both cases starting from a compound of the formula IVA*(alone or less preferably in mixture with a compound of the formula VA*);
or of the formula XB shown above with a compound of the formula IX shown above or a borane adduct thereof, or to a compound of the formula XB* shown above with a compound of the formula IX* shown above or a borane adduct thereof, in both cases starting from a compound of the formula from IVB* (alone or less preferably in mixture with a compound of the formula VB*),
in the case of mixtures of compounds of the formula IVA* and VA* or IVB* and VB* preferably after isolating the compounds of the formula IVA* or IVB*, respectively, from the undesired enantiomer of the formula VA* or VB*.

10. The process according to claim 9, further comprising reacting the compound of the formula VIIIA or VIIIB with a phosphine of the formula IX or IX*,

R_3-PH_2 (IX)

H_2P-R_3*-PH_2 (IX*)

(or the corresponding borane adduct thereof) wherein R_3 is a monovalent, R_3* a bivalent organic moiety that can be bound to phosphorus, resulting in a phospholane compound of the formula XA or XA* (from VIIIA); or XB or XB* (from VIIIB) shown in claim 5, respectively.

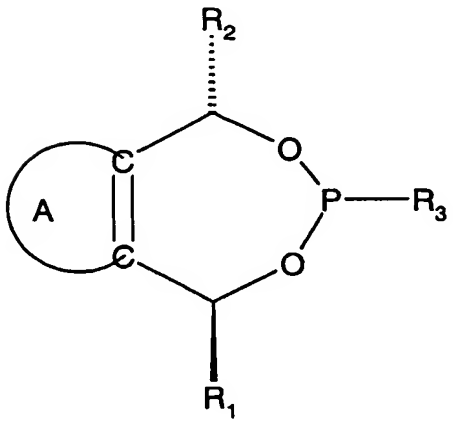
11. A process for the preparation of a ligand of the formula XIIA or XIIA* shown below from a compound of the formula IVA or of the formula XIIB or XIIB* shown below from a compound of the formula IVB,
comprising

a) reacting a compound of the formula IVA or IVB with a compound of the formula XI or XI*,

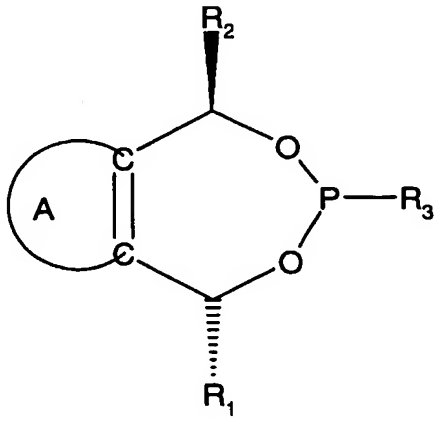
R_3-$P(L)_2$ (XI)

$(L)_2$-P-R_3*-P-$(L)_2$ (XI*)

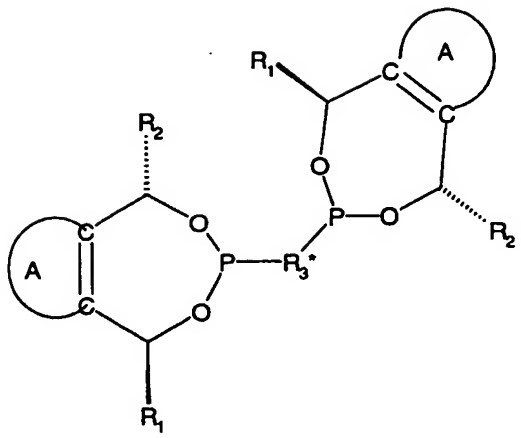
wherein R_3 is a monovalent, R_3* a bivalent organic moiety that can be bound to phosphorus and L is a leaving group, leading to ligands of the formula XIIA or XIIA* (from IVA) and/or XIIB or XIIB* (from IVB),



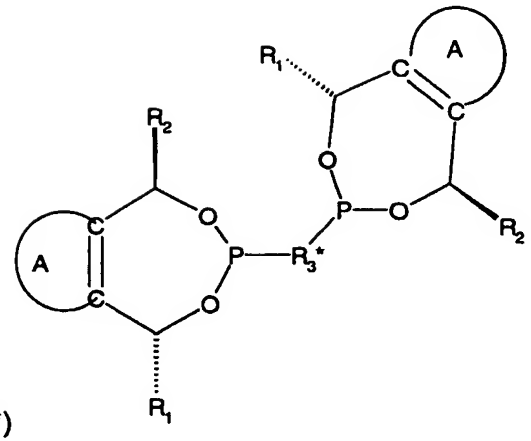
(XIIA)



(XIIB)



(XIIA*)



(XIIA*)

wherein ring A, R_1 and R_2 have the meanings indicated for compounds of the formula IVA and IVB and R_3 is a monovalent, R_3^* a bivalent organic moiety that can be bound to phosphorus; or

b) reacting a compound of the formula IVA or IVB with a compound of the formula XI** or XI***,

R_3-P[N(alk)$_2$]$_2$ (XI**)

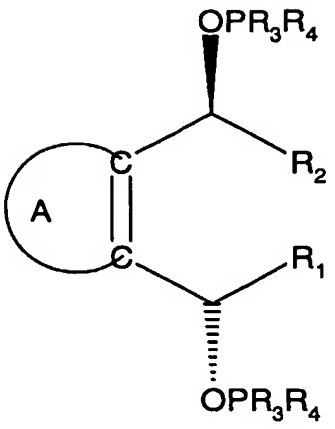
[(alk)$_2$N]$_2$P-R_3^*-P[N(alk)$_2$]$_2$ (XI***)

wherein R_3 is a monovalent, R_3^* a bivalent organic moiety and
alk is alkyl which can be linear or cyclic, especially lower alkyl, in particular methyl, ethyl, I-propyl or butyl, or is a heterocyclic radical, under removal of the secondary amine HN(alk$_2$)$_2$, yielding the compound of formula XIIA or XIIA* (from IVA); or XIIB or XIIB* (from IVB) described above, respectively.

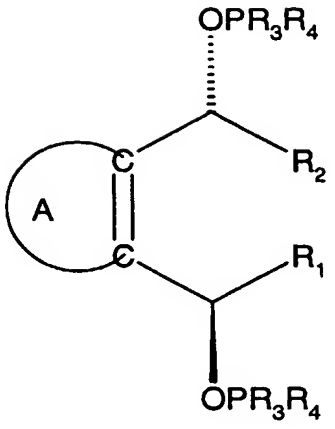
12. A ligand of the formula XIIA, XIIA*, XIIB or XIIB*, as shown in claim 11.

13. A transition metal complex comprising a ligand of the formula XIIA, XIIA*, XIIB or XIIB*, as shown in claim 11.

14. A process for the preparation of a ligand of the formula XIVA from a compound of the formula IVA or of the formula XIVB from a compound of the formula IVB,



(XIVA)



(XIVB)

wherein ring A, R_1 and R_2 are as defined for compounds of the formula XIVA or XIVB in claim 1 and R_3 and R_4 each are, independently of the other, an organic moiety that can be bound to phosphorus,

said process comprising reacting a compound of the formula IVA or VIB given in claim 1, respectively, with

a) a compound of the formula XIII,

$$R_3R_4P\text{-}L \qquad (XIII)$$

wherein R_3 and R_4 are organic moieties that can be bound to phosphorus and L is a leaving group, resulting in a compound of the formula XIVA (from IVA) or XIVB (from IVB), respectively; or

b) with a compound of the formula XIII*,

$$R_3R_4PN(alk)_2 \qquad (XIII^*)$$

wherein R_3 and R_4 are, independently form each other, an organic moiety and alk is alkyl which can be linear or cyclic, especially lower alkyl, in particular methyl, ethyl, l-propyl or butyl, or is a heterocyclic radical, under removal of the amine $H_2N(alk)_2$.

15. A ligand of the formula XIVA or XIVB, as shown in claim 14.

16. A transition metal complex comprising a ligand of the formula XIVA or XIVB, as shown in claim 14.

17. The use of a phosphorus containing ligand according to any one of claims 6, 12 and 15 or a transition metal complex of either ligand type according to any one of claims 7, 13 and 16 in an asymmetric reaction or as an asymmetric catalyst.